Biochar Field Trial in San Mateo County, California:

Presented to AQWA
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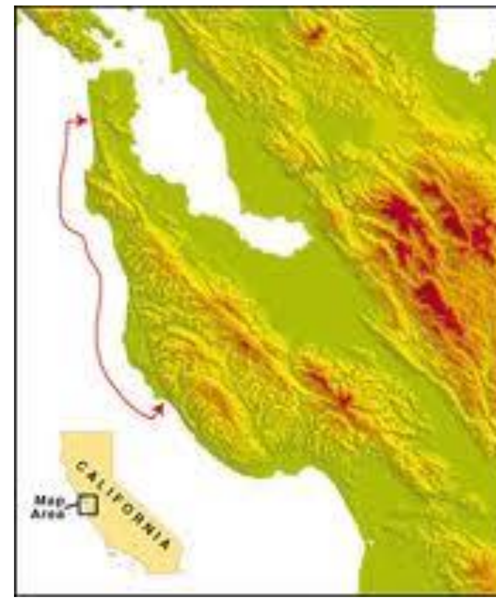

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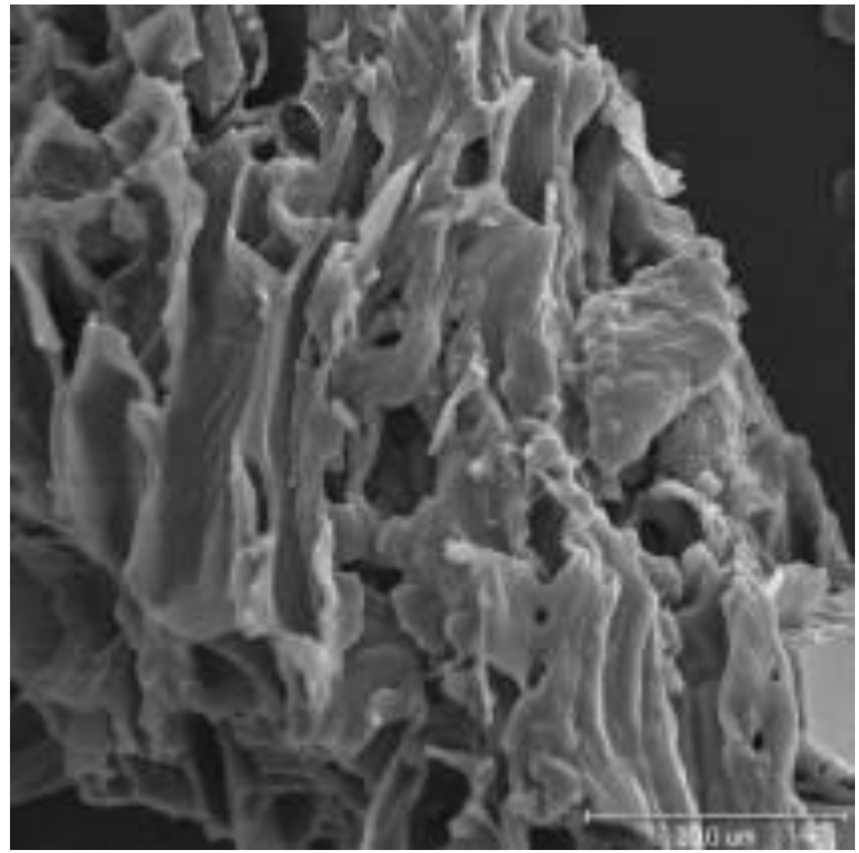
What is Biochar?

- Ancient soil amendment- charcoal
- Pyrolysis of organic biomass (slow burning in low-oxygen/high temp)

Properties of Biochar

- Varies depending on parent material- carbon preserved
- Porous, highly ionized particles
- Highly stable in soil
- Slow decay

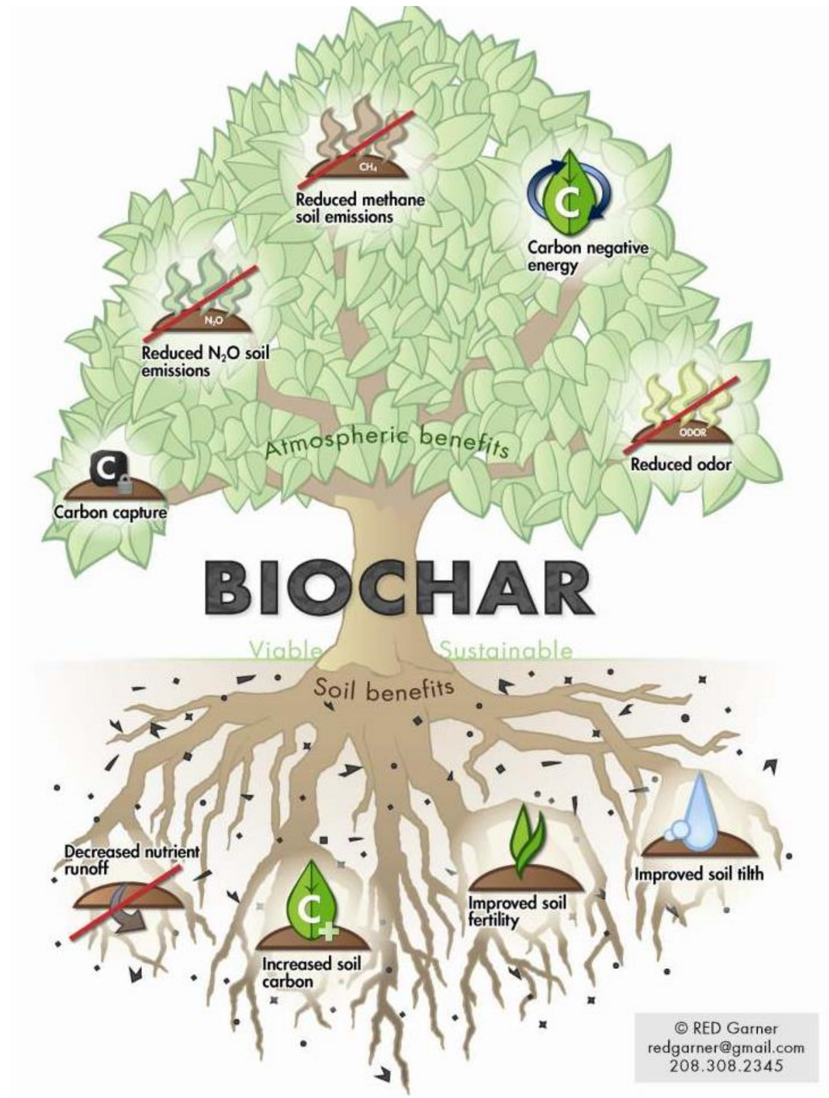


When applied as a soil amendment in agricultural operations…….

Biochar has been shown to improve crop yield, soil health, nutrient retention and have climate change benefits

How?

- Slow release fertilizer
- Increase soil carbon and storage
- Increase water holding capacity
- Decrease nitrous oxide emissions and nitrate leaching
- Diversified microbial assemblages
- Positive feedback loops



RCD Biochar Field Trial Project

The purpose of our study was to demonstrate the use of biochar in conventional row crop operation in the local climatic and soil conditions of coastal San Mateo County

Our goals were to assess:

- Effects of biochar on crop yield, soil health, nutrient retention and carbon sequestration
- Cost/benefit to farmers
- Barriers and opportunities to local biochar use

Project Tasks

- Field trial
  - Crop yield and soil monitoring
- Cost/benefit analysis
  - Labor, materials, crop yield etc.
- Barriers and opportunities analysis
  - Sources, application methods, feasibility
- Report and distribute results

Field Trial

- Site Identification
  - Conventional row crop operation (Brussels sprouts) in Half Moon Bay, CA

- Baseline Data
  - On farm practices
  - Soil monitoring
  - Crop yield data

Field Trial Methods

- A Guide to Conducting Biochar Trials (2009): International Biochar Initiative (IBI)
- Spring 2012-Fall 2014
- Two test plots of 16 square subplots:
  - 4 control, 4 biochar, 4 compost, 4 biochar-compost mix
- One-time application at 10-20 tons/acre with rakes
- Existing farming practices preserved

Soil Amendment Application

Field Trial Monitoring

- Crop Yield
  - Weigh Brussels sprouts stalk and fruit in the fall

- Soil
  - Spring and Fall samples
    - Composite nutrient analysis (0-6”, 6-12”)
    - Nitrate-N analysis (12-24”, 24+”)
  - Fall samples
    - Bulk density analysis

Analysis Methods

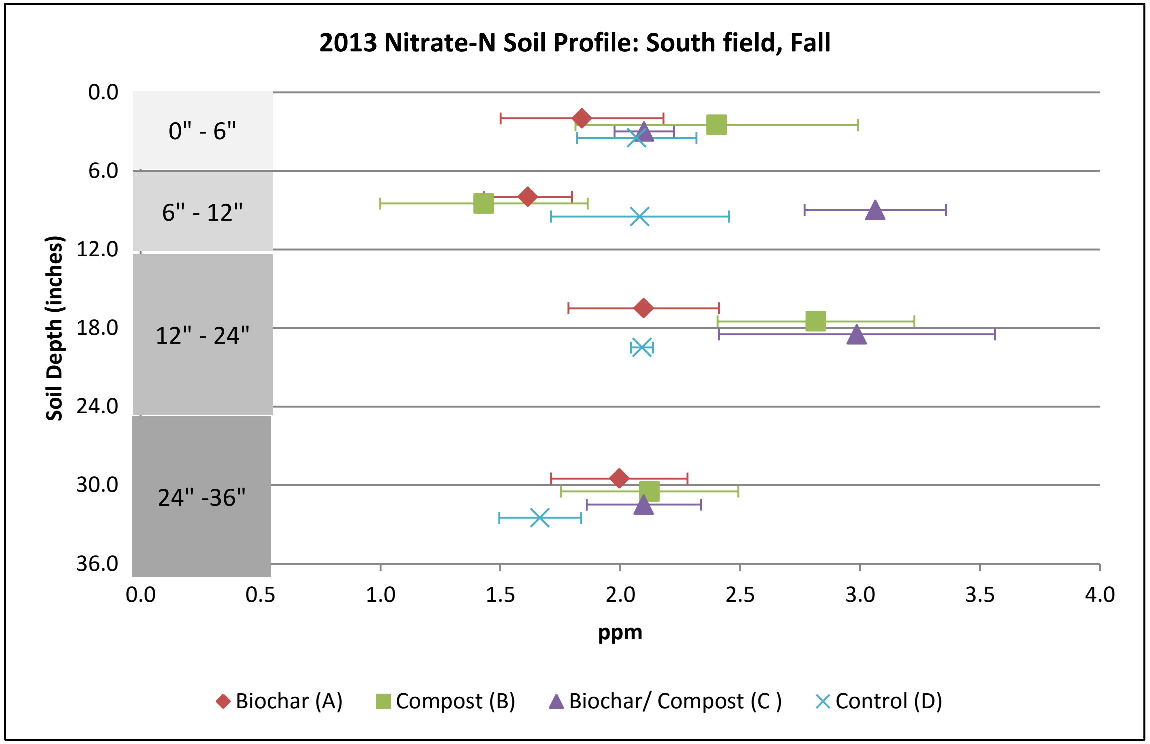
- Crop Yield
  - Fruit yield totals from treatments: % difference from control
  - Averaged stalk + fruit weight per treatment
- Soil
  - Compare treatment averages to control and recommended ranges for Brussels sprouts growth in this location

Indicator	Recommended range
Bulk density (loam, clay loam)	<1.4 g/cm3
Soil porosity below 24”	Leaching: <40%
Electrical conductivity	0.2- 4.0 dS/m
pH	6.5 -7.5
Cation exchange capacity	10-25 meq/100g

Nutrient	Recommended range
Nitrogen as nitrate (nitrate-N)	10-50 ppm
Nitrogen as ammonium (ammonium-N)	5-25 ppm
Phosphorus (P)	22-65 ppm
Potassium (K)	246-409 ppm
Boron (B)	1-4 ppm

Analysis Methods

- Nitrate Leaching
  - No direct measurement
  - Soil profiles used to ID trends over time compared with control



- C-Sequestration
  - Calculated initial C additions from treatments
  - Measured SOC to ID trends over compared with control

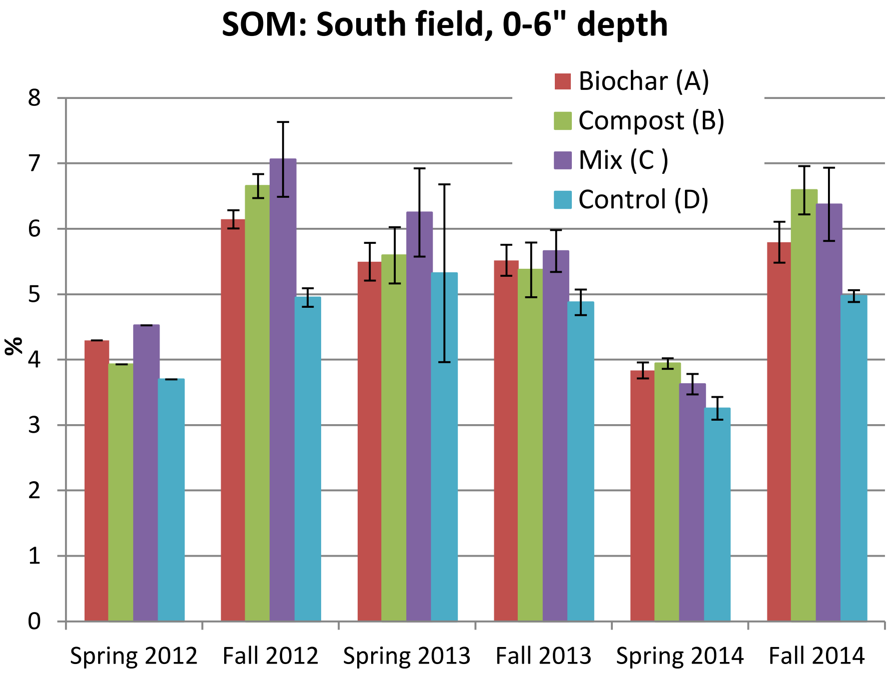
Crop Yield Findings

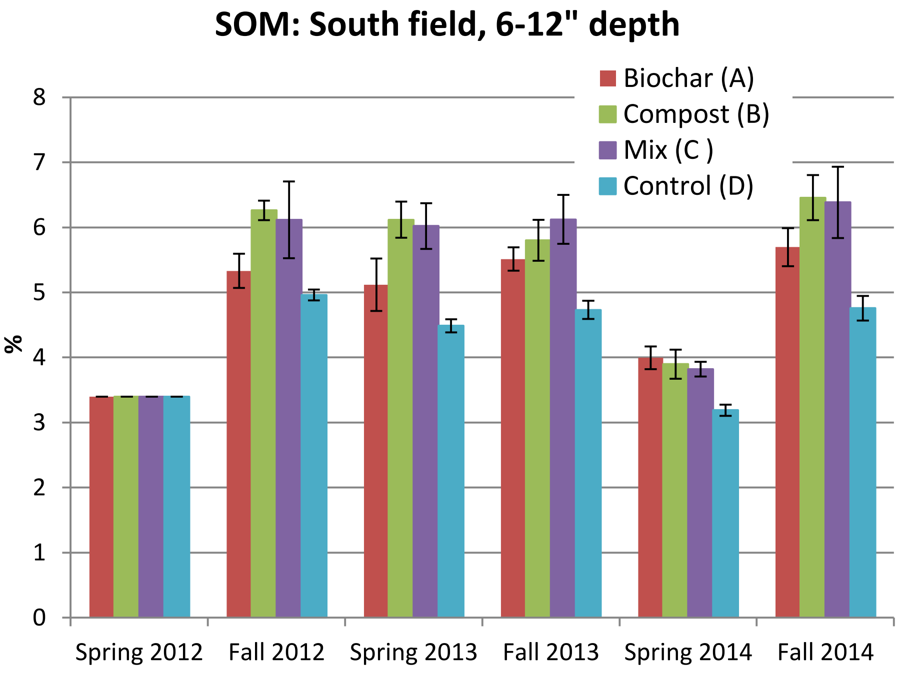
- Biochar-only and biochar-compost mix soil amendments had neutral or negative effects on crop yields
  - Lime application may have masked biochar benefits
  - Biochar may have bound to nutrients initially and decreased nutrient availability during this short-term (3-year) study
- Compost-only treatment had a neutral or positive affect on crop yields
  - Compost may have increased soil organic matter (SOM) particularly in SOM deficient soils

NORTH	Percent change from control			
Treatment	2012	2013	2014	All years
Biochar	-4	-3	-6	-5
Compost	-4	+1	-2	-2
Mix	-15	-2	-6	-9
SOUTH	**Percent change from control**			
Treatment	**2012**	**2013**	**2014**	**All years**
Biochar	-6	+12	-5	-2
Compost	+10	+10	-2	+5
Mix	-5	+16	-10	-2

Soil Health Findings

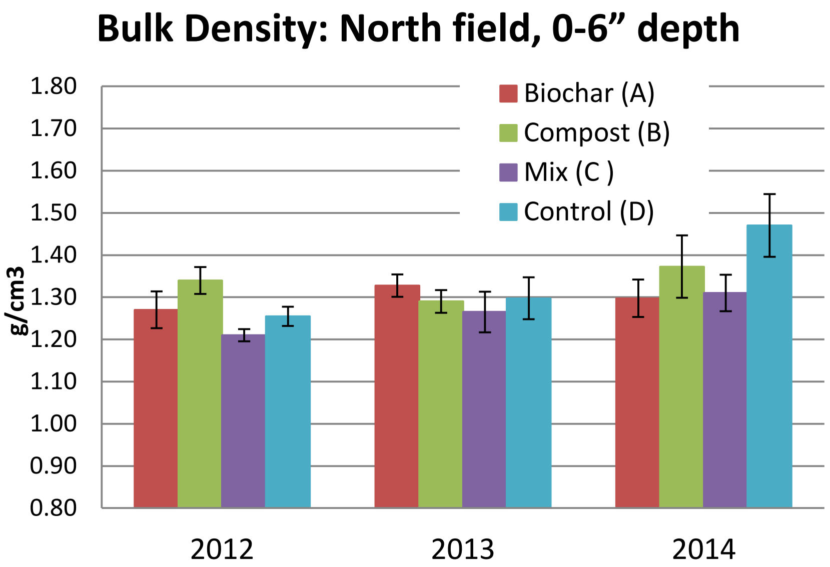
- Increased soil organic matter (SOM) levels in SOM-depleted soils

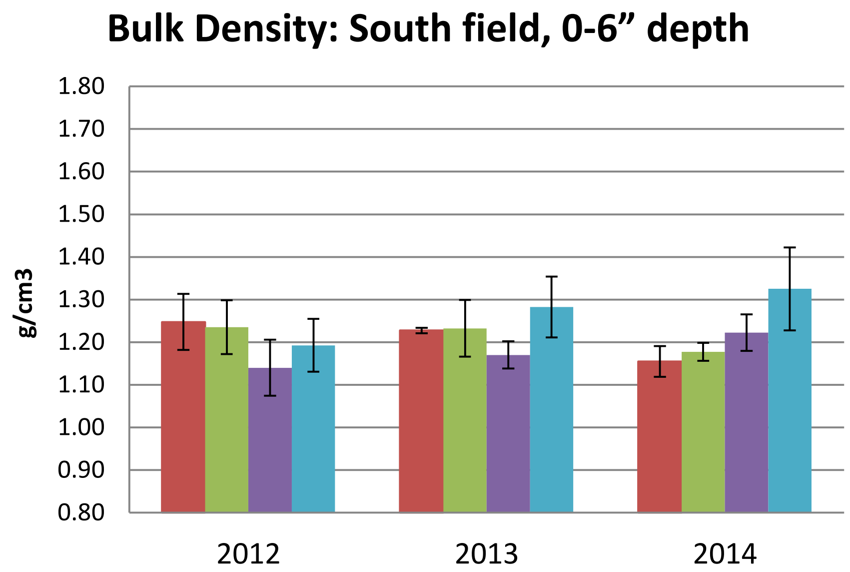




Soil Health Findings

- Multi-year, stabilizing effect on bulk density





- Increased nitrate-N concentrations (slightly) in root zone over the growing season
- Increased Boron concentrations (slightly) in Boron-depleted soils

Nitrate Leaching Findings

- Nitrate soil profiles used to draw inferences
- No significant effects of treatments
  - Slight trend: Higher nitrate concentrations in upper vs. lower soil layers (Both biochar soil amendments)
- Biochar-nitrogen dynamics are complex especially within an active farming operation
  - Plowing, tilling, disking, lime application, fungicide, fertilizer etc.

Carbon Sequestration Findings

- Carbon sequestration from soil amendment biomass (tons/acre total soil organic carbon):
  - Biochar: 6.0
  - Compost: 2.3
  - Mix: 8.3

- No conclusive trends to show carbon sequestration benefit
  - Soil monitoring was too short
- Other potential carbon sequestration benefits not quantified:
  - Higher, more diverse microbial activity → Increased carbon storage
  - Slow-release fertilizer → reduced need for fertilizer/GHG production

Cost-Benefit Analysis

- 2 scenarios of biochar application:
  - 1 ton/acre: Benefit accrues with 1-2% increased crop yields over three years (or >5% in one year)
  - 10 tons/acre: Benefit accrues with 13% increased crop yields over three years (or 37-40%) in one year)
- Cost and inconvenience can be major drawbacks
- Potential benefits from soil health, nutrient retention and climate change should also be considered

Barriers and Opportunities Analysis

- High cost of material
- Few local suppliers
  - Produce biochar on-site?
- Transport & storage difficulties
- Challenges with application methods and equipment
- Operationalize with NRCS conservation practice standard

Conclusions and Next Steps

- Biochar use in a conventional agricultural operation in coastal San Mateo County was successfully demonstrated
- Results largely inconclusive besides benefits to soil health
- Potential influencing factors:
  - Extreme weather conditions (heat and drought)
  - Study too short
  - Influence of on-farm practices
- Substantial costs and barriers
- Future studies
  - Rate and timing of application, isolation of variables, longer study

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